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ABSTRACT

Ideas that have been developed in the decision support systems (DSS) literature that seem particularly relevant to institutional research, planning, and analysis (IRPA) are reviewed. In addition, a survey of practitioners in Canadian universities that provides new information on the rapidly changing current state of information technology, including DSS and IRPA, is examined. The roots of the study of DSS are traced to the theoretical studies of organizational decision-making done at the Carnegie Institute of Technology and the technical work on interactive computer systems carried out mainly at the Massachusetts Institute of Technology. The DSS approach assumes that effective design depends on the technician's detailed understanding of decision processes and the manager's appreciation of the criteria for developing useful computer-based decision tools. The institutional research literature that encompasses computer-based models was greatly influenced initially by the early research on the use of computer models in university planning and administration done for the Commission on the Financing of Higher Education (the Bladen Commission) in Canada. Among the findings of a 1982 survey of 35 Canadian universities are the following: 80 percent of the departments have computer terminals; 60 percent of the IRPA offices have word processing equipment; most offices are using computer-based simulation for budgeting, planning, space allocation, or scheduling; a quarter of the offices have experience in the use/development of DSS; and less than 15 percent of the offices have been involved in DSS purchases or evaluation. A bibliography is appended. (SW)

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DECISION SUPPORT SYSTEMS:

AN INSTITUTIONAL RESEARCH PERSPECTIVE

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This paper was presented at the Twenty-Second Annual Forum of the Association for Institutional Research held at the Denver Hilton Hotel in Denver, Colorado, May 16-19, 1982. This paper was reviewed by the AIR Forum Publications Committee and was judged to be of high quality and of interest to others concerned with the research of higher education. It has therefore been selected to be included in the ERIC Collection of Forum papers.

D. R. Coleman, Chairman
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DECISION SUPPORT SYSTEMS: AN INSTITUTIONAL RESEARCH PERSPECTIVE

- Abstract -

Change in information technology including the evolution of decision support systems used in industry make it prudent for institutional researchers to reexamine institutional use of computer-based information systems in support of decision making. This paper reviews the decision support systems literature and the parallel (but separate) institutional research literature. The results of a survey of Canadian universities to determine the current state of information technology in institutional research practice are presented. These show that nearly all senior practitioners anticipate that changing information technology will impact their own practice of institutional research.

DECISION SUPPORT SYSTEMS: AN INSTITUTIONAL RESEARCH PERSPECTIVE

Advances in computers and communications over the past decade have resulted in a generation of information systems characterized by declining costs and increased performance. The emerging technology makes it practical to bring the computer directly to the user (manager) via terminals and desk-top computers. Since, the purpose of institutional research is to gather information to support decisions in postsecondary education, we have a fundamental interest in information systems. As data providers we are interested in information systems characteristics, as information-for-decisions providers we are interested in how one can interact with information systems to better assist the institutional decision process and as institutional research theoreticians we are interested in how potential characteristics of information systems may be realized in every day institutional research practice over the next few years.

This paper reviews the notions that have been developed in the decision support systems (DSS) literature that seem particularly relevant to institutional research, planning and analysis (IRPA). The corresponding IRPA literature are cited along with the observation that for the nearly two decades these fields have evolved there has been very little cross-reference. While the savvy practitioner familiar with the IRPA literature may not find a flood of new concepts in the DSS literature and case studies, nonetheless, the broader perspective of this literature, its soundness and practicality make it an important potential source of new insights valuable to IRPA. The paper concludes with the results of a survey of practitioners in Canadian universities which provide new information on the rapidly changing current state of information technology, including DSS, in IRPA.

Decision Support Systems

The roots of the study of DSS are traced to the theoretical studies of organizational decision making done at the Carnegie Institute of Technology

and associated with the names Simon (1960), Cyert and March (1963), and others, and the technical work on interactive computer systems, carried out mainly at the Massachusetts Institute of Technology in the 1960s and associated with Licklider (1960) and MIT's project MAC. Morton (1971) is said to be the first explicit meshing of these threads.

The DSS approach assumes effective design depends on the technician's detailed understanding of decision processes and the manager's appreciation of the criteria for developing useful computer-based decision tools. DSS are intended to impact decisions in which there is sufficient structure for computer and analytical aids to be valuable, but where manager's judgement is essential. These are supportive tools which remain under the decision maker's own control, which do not attempt to automate or make more efficient, the decision process, but which can make the manager more effective. This is not to downgrade the advances which made computers more reliable, cheaper, more user friendly, flexible and allow "interactive" computer systems. The answer to the question of where DSS fits into the overall field of computer-based management information systems is illustrated by the following comparisons. Computer science creates technology, both hardware and software. Management science represents the analytical viewpoint in structuring problems and develops models. Behavioral science provides insight into the implementation process, and the human and organizational context of the system. Data processing professionals build the application systems and management understands the realities of decision making and thus, which systems can be effective. Finally, decision support focusses attention on building systems in relation to the key decisions and tasks, with the specific aim of improving effectiveness of the managers' problem-solving process (Keen and Morton, 1978).

Support implies a descriptive approach to the decision process while

improvement implies a prescriptive approach. Improving decision making requires supporting managers and helping them adapt, learn and move toward the prescriptive position. They may be both unwilling and unable to do this if the system does not start from their perspective. Keen and Morton (1978) note the five main points of view on decision making in the literature as the economic/rational concept, the satisficing/process-oriented view, the organizational procedures view, the political view, and the individual differences approach. Each of these views contribute to the way we think of decision making. Since there is no right way to look at the decision process for a given situation, the "correct" way may involve a blend of all five points of view or the particular context may make one of them the most relevant (for IRPA literature on decision processes see Schmidtlein (1975) and Weathersby (1975)).

The following framework for information systems proposed by Keen and Morton is an elegant description of DSS. The matrix classifies decision making in relation to potential computer support and builds on the unidimensional taxonomies of Anthony (1965) for management activities and Simon (1960) for types of decisions.

	MANAGEMENT ACTIVITY			
TYPE OF DECISION	Operational Control	Management Control	Strategic Planning	Support Needed
Structured	1	4	7	Clerical, EDP, MS Models
Semistructured	2	5	8	DSS
Unstructured	3	6	9	Human Intuition

The framework suggests that builders of DSS for semistructured decisions need different skills and attitudes than those people building systems for structured decisions in part because the technology that supports semistructured tasks is different from the computer power used in a typical data processing shop. The DSS construction process is more like an ongoing evolutionary service than the preparation of a final product. One of the strengths of the DSS approach is

that it is firmly rooted in the management reality; technique is subordinate to application. In many ways, most DSS are comparatively trivial on a technical level but in terms of management and application state-of-the-art they are innovations.

Three levels of technology along with five roles assumed by people involved in the development process are posited by Sprague (1980, 1981) to help the definitional questions that remain moot at this stage in the evolution of the DSS movement. The specific DSS is an application including hardware/software which allows the decision maker to deal with a specific set of related problems. A DSS generator is a package of hardware and software which provides the capabilities to build quickly and easily a specific DSS. DSS generatores are evolving from enhanced planning languages or modeling languages often with report preparation and graphic display capabilities added. The interactive financial planning system (Execucom 1980) and EXPRESS available from TYMSHARE are examples. End user languages which eliminate the need for programmers are an important development in this area (Martin, 1982). DSS tools are hardware or software elements which facilitate the development of a specific DSS or a DSS generator. A spectrum of five roles may be spread across these three types of DSS. The manager (user) is the person faced with the problem for decision and with responsibility for the consequences. The intermediary helps the user, perhaps merely as a clerical assistant to push the buttons of the terminal, or perhaps as more substantive "staff assistant" to interact and make suggestions. DSS builders arrange the necessary abilities from the DSS generator to assemble specific DSS. This person must be familiar with the problem area and comfortable with information system technology. The technical supporter develops additional information system abilities or components when they are needed as part of the generator including new data bases, new analysis models, and additional data display formats.

Finally, the toolsmith, develops new technology, new languages, new hardware and software.

The DSS builders viewpoint isolates three categories of characteristics (Sprague, 1981) of DSS: Dialogue management includes the ability to handle a variety of dialogue styles (e.g. novice to expert), the ability to accommodate users in a variety of media (e.g. with light pens, function keys, touch panels), an ability to present data in a variety of formats and media (e.g. with color graphics, plotters, audio-output); data management includes the ability to combine a variety of data sources, the ability to portray logical data structures in user's terms so the user understands what is available, and can specify needed additions and deletions; model management includes the ability to create new models quickly and easily, and the ability to manage the model base with management functions analogous to data management (e.g. mechanisms for storing, cataloguing, linking and accessing models).

Keen's (1980) view is that personal systems to assist the decision maker must be built from the decision makers perspective it must be based on a very detailed understanding of how managers make decisions and how his or her organization functions. Keen's "modest proposal" (1976) and the "three hat theory" from the IRPA literature (Sheehan, 1974) share many ideas on senior managers and computer-assisted decision making. Since DSS can have many different connotations Alter's Taxonomy (Alter, 1980) helps to elaborate the range of computer-based MIS included (by some authorities) in the set. The taxonomy is based on the "degree to which the system's output can directly determine the decision". This effect is related to generic operations that can be performed by DSS including: retrieving a single item of information, providing a mechanism for ad hoc data analysis, providing prespecified aggregations of data in the form of reports, estimating the consequences of proposed decisions, proposing decisions and making decisions.

Alter's review of 56 systems suggested the following taxonomy of DSS. File drawer systems allow immediate access to data items. Data analysis systems allow the manipulation of data by means of operators tailored to the task or operators of a general nature. Analysis information systems provide access to a series of data bases and small models. Accounting models calculate the consequences of planned actions on the basis of accounting definitions. Representation models estimate the consequences of actions on the basis of models which are partially nondefinitional. Optimization models provide guidelines for action by generating the optimal solution consistent with the series of constraints. Suggestion models perform mechanical work leading to a specific suggested decision for a fairly structured task. For a report on use of the Taxonomy in Canada see Grindley et al (1981). Alter makes the following interesting prediction. "Rather than a technical innovation, the key issue for DSS in the next decade may simply be the diffusion of the idea that computers can be used to support (rather than replace) decision makers" (page 192). In elaborating the characteristics of system types in the taxonomy, Alter differentiates systems on the basis of: type of task, hands-on user, decision maker, key role, key usage problem, system initiator, key design and implementation problem, key change issue, key technical problem.

Institutional Research, Planning and Analysis

The institutional research literature that encompasses computer-based models was greatly influenced initially by the early research on the use of computer models in university planning and administration done for the Commission on the Financing of Higher Education (the Bladen Commission) in Canada. A report to the Commission (Judy and Levine, 1965) illustrated the first CAMPUS model. The authors refer to the work of Robert McNamara, McKean (1958), Hitch and McKean (1960), the Rand Corporation and others. They noted in their report "The system simulation model does not 'automate' any decisions. Its role

is entirely that of a tool that can greatly improve the information with which university planners and decision makers work." There followed much important literature on the CAMPUS models from the Office of Institutional Research and the Institute for Quantitative Analysis of Social and Economic Policy, University of Toronto and from the Systems Research Group.

The intervening years have seen evolution of these models and institutional researchers, planners and analysts around the world have gained a good deal of practical experience - and a healthy skepticism about applications of management science in higher education, as illustrated by the following observations. "I used to think that our problems would be solved if we could only entice more systems analysts away from the aerospace program. I don't now." (Hansen, 1972). "The experimentation with computer models in the planning and management of colleges and universities had led to much disenchantment and disappointment." (Mason, 1976). But lately, there seems to be cause for more optimism, "This resurgence is the result of the confluence of five factors: institutions' current need for improved decision making, the learning about the do's and don't's of modeling that has taken place during this period, the widely publicized success of modeling at Stanford University, the improvement in modeling-system software, and, finally, the availability of new delivery systems" (Updegrove, 1981). The Stanford experience (and more) is given in Hopkins and Massy (1981), see also Wyatt et al (1979).

It is, of course, not possible to review here the related institutional research literature but the interested reader will find much of this fascinating story in the sourcebooks, New Directions for Institutional Research, particularly, Wallhaus (1975), Mason (1976), Hopkins and Schroeder (1977), Adams (1977), Staman (1979), Poulton (1981) and Sheehan (1982). The Ford Foundation Program for Research in University Administration is a source of some of the early important work. The numerous reports are listed and some are summarized

in the program's final report (Ford Foundation, 1973). Some of the other earlier work include Weathersby (1967), Johnson and Katenmeyer (1969), Minter and Lawrence (1969), Weathersby and Weinstein (1970), Gulko (1971), Hopkins (1971), Schroeder (1973), Heinlein (1974), Bloomfield (1975) and Adams (1975).

In comparing the two literatures it is instructive to observe that there is virtually no cross-reference. For example, none of the 32 authors of the recent handbook of planning and institutional research (Jedamus and Peterson, 1980) mentions DSS and there is no reference to institutional research in Decision Support Systems: An Organizational Perspective (Keen and Morton, 1978) the most widely quoted text on DSS. Yet, the opportunities provided by changing information technology make it imperative that IRPA practitioners learn from those experienced in DSS. Also, there is an heightened analytic orientation among top administrators which may tend to quicken practical DSS developments (Rochart and Treacy, 1982). Hence, it is important to take stock of our current position so that the anticipated developments can be monitored and evaluated.

Survey of Canadian Practitioners

Accelerating development of information technology and the maturation of IRPA suggest the possibility of rapid and significant changes in the practice of institutional research and protend profound impacts on the careers of those in this profession. Table I gives a snapshot of the state of information technology in institutional research in Canadian universities in winter 1982. Questionnaires were mailed to 36 universities and 35 responses are included in the results. Questionnaires were sent to the senior institutional research person (or member of AIR) on practically every university campus in Canada.

The results show that while 80% of the departments have computer terminals, less than half the senior persons use the devices themselves. There seems to

TABLE I

Information Technology Use in Departments of Institutional Research, Planning and Analysis in Canadian Universities

Activities, Opportunities and Director's Opinions Surveyed	Larger Offices[1] % Yes	MIS/Computer Offices[1] % Yes	All Offices[3] Yes #	All Offices[3] No #	All Offices[3] Yes[2] %
Department has a Computer Terminal	100	100	28	7	80
Director Personally Uses Computer Terminal	63	70	16	19	46
Department Regularly Uses:					
Word Processing Equipment	63	70	21	14	60
Videodisc Equipment	0	0	0	33	0
Computer Color Graphics	36	30	6	27	17
Mini/Micro/Personal Computers	45	60	10	23	29
Institutional Electronic Mail System on Campus	45	60	12	22	34
Director Personally Sends/Receives E-M Messages	18	20	5	30	14
Department Using Computer-Based Simulation Models	100	100	23	10	66
For: Budgeting	73	80	15		43
Planning	45	50	13		37
Scheduling	36	20	4		11
Space Allocation	36	30	6		17
Administrator(s) on Campus Use DSS	63	70	13	22	37
Department Has Been Involved With DSS Through:					
Use	55	50	9		26
Development	55	40	9		26
Purchase	18	10	2		6
Evaluation	18	10	3		9

Table I (Continued)

Activities, Opportunities and Director's Opinions Surveyed	Larger Offices[1] % Yes	MIS/Computer Offices[1] % Yes	All Offices[3] Yes #	No #	Yes[2] %
Campus Environment is:					
Data File	9	10	4		11
Data Base	18	30	7		20
Mixed	73	60	19		54
Other	0	0	3		9
Over the Next Five Years, Changing Information Technology will:					
Influence IRPA practice on campus significantly	82	80	29	5	83
Influence your own professional activities	100	100	31	4	89
Be generally good for universities	63	70	28	2	80

[1] The "Larger" offices are the 11 offices with 6.0 or more FTE staff and the "MIS/Computer" offices are the 10 offices which report holding full membership on university-wide management information systems or administrative computing committees. These offices were identified by descriptions reported in The University of Calgary Survey (Hillman, 1982).

[2] Percentage column is percent yes of total 35 respondents to this survey.

[3] The thirty-five offices included were: Alberta, U. of; Athabasca, U. of; British Columbia, U. of; Calgary, U. of; Carleton U.; Concordia U.; Guelph, U. of; Laurentian, U. of; Laval U.; Lethbridge, U. of; McGill U.; McMaster U.; Manitoba, U. of; Montréal, U. de; Mount St. Vincent U.; New Brunswick, U. of; Ottawa, U. d'; Québec à Montréal, U. du; Québec à Rimouski, U. du; Québec à Trois-Rivières, U. du; Queen's U.; Regina, U. of; St. Mary's U.; Saskatchewan, U. of; Simon Fraser U.; Télé U.; Toronto, U. of; Trent U.; Victoria, U. of; Waterloo, U. of; Western Ontario, U. of; Wilfrid Laurier U.; Windsor U. of; York U.

be a fair amount of information technology used in these IRPA offices since 60% have word processing equipment, one in six use computer color graphics regularly,, and one in three have mini/micro/personal computers. Although about a third of the campuses offer an electronic mail service only a few senior practioners personally use electronic mail. No one reported use of videodisc equipment in their offices yet.

Most offices are using computer-based simulation models and of these two-thirds support budgeting, about 60% are for planning, 25% are for space allocation and 15% are for scheduling. In addition at least one respondent identified one of the following functions as currently supported by computer-based simulation models; revenue forecasting, income projection, space entitlement, resource implications of enrolment downturn, institutional grant allocation, collective bargaining, salary and other financial studies, student flow and faculty flow. In order to get some insight into the broader level of information systems on Canadian university campuses, each respondent was asked to place his or her institution in a simple spectrum. One in five described the campus environment as data base, while only one in ten said data file and nearly 55% said the environment was mixed.

Just over a third of the senior institutional researchers, planners and analysts surveyed could identify an administrator on their campus using a DSS. Given the broad interpretation possible the questionnaire proposed the following working definition for DSS: "For purposes of this study, let's argue that a decision support system (DSS) is a computer-based system which assists managers in their planning, problem solving and judgement with respect to tasks which cannot be routinized. DSS tend to be personal tools under the individual decision maker's control and may even be tailored to his/her terminology." A quarter of the offices have experience in the use and the same number in the development of a DSS. Less than 15% have been involved in DSS purchases or evaluation.

Given their professional predeliction for anticipation, the senior practitioners were asked their personal opinion on the impact of changing information technology over the next five years. More than 80% said information technology would significantly influence the practice of IRPA on their campuses, nearly 90% felt it would influence their own professional activities and while 80% saw changing information technology as being generally good for universities, 20% felt it would not be, or were noncommittal.

Given the eclectic approach to the provision of institutional research services in universities, it would be valuable to differentiate information technology use on the basis of office characteristics. In this regard, it is interesting to compare the state of information technology as described by the senior practitioners in the larger offices, and in those offices which may have an orientation to management information systems or administrative computing activities, with the response from all 35 institutions. These subsets were identified from the results of a recent survey of 22 Canadian universities (Hillman, 1982). Table I shows that all the offices in the Larger and MIS/Computer subsets have computer terminals, all use computer-based models and all respondents expect that changing information technology will influence their own professional activities. The MIS/Computer subset respondents are more inclined to use a computer terminal and electronic mail and their departments use word processing and mini/micro/personal computers more than the larger office subset and both subsets score higher on these measures that "All Offices". Both the MIS/Computers subset and the senior practitioners in the larger offices are significantly more likely to be aware of at least one campus administrator using a DSS and their own offices have been much more involved in the use and development of DSS than the average Canadian university office of IRPA.

Conclusion

The theoretical advances in DSS, the rapid change in information technology which enhances the practical applications of these systems in all organizations, and the increased use of information technology on campus with the accompanying widespread improvement in computer literacy suggest that there will be more institutional attention paid to information systems to support decision making. It is therefore opportune for IRPA to reevaluate all aspects of their current and anticipated uses of computer-based information systems.

References

Adams, C.R. How managers view information systems. Decision Sciences, 1975 6(2), 337-345.

Adams, C.R. (Ed.) New directions for institutional research: appraising information needs of decision makers. No. 15. San Francisco: Jossey-Bass, 1977.

Alter, S.L. Decision support systems: current practice and continuing challenges. Reading, Mass.: Addison-Wesley, 1980.

Anthony, R.N. Planning and control systems: a framework for analysis. Cambridge, Mass.: Harvard University Graduate School of Business Administration Studies in Management Control, 1965.

Bloomfield, S.D. A committed resources approach to faculty staffing policies. In R. Cope (Ed.) Information for decisions in postsecondary education. The Association for Institutional Research, 1975. pp. 69-72.

Cyert, R.M. and J.G. March. A behavioral theory of the firm. Englewood Cliffs, N.J.: Prentice-Hall, 1963.

Execucom Systems Corporation. Interactive financial planning system. Austin, Tx.: Execucom Systems Corporation, 1980.

Ford Foundation Program for Research in University Admininstration. Final Report. Office of the Vice President-Planning. Calif.: University of California. October, 1973.

Grindley, A., S. Rivard, S. Huff and P. Suttie. Decision support systems in Canada. In L. Gingras, (Ed.) Information systems and accounting. Administrative Sciences Association of Canada, Conference, Halifax, N.S.: ASAC 1981. pp. 31-40.

Gulko, W.W. The resources requirements prediction model (RRPM-1) an overview. Technical Report-16. Boulder, Colo.: Planning and Management Systems Division, Western Interstate Commission for Higher Education (WICHE) 1971.

Hansen, B.L. The impact of management science in the university on the professor's life style. Canadian Journal of Higher Education, 1972, II(2), 17-23

Heinlein, A.C. (Ed.) Decision models in academic administration. Kent, Ohio: The Decision Science Institute of the Center for Business and Economics, Kent State University, 1974.

Hillman, E.A. Survey of organization and operations of offices of institutional research/analysis/planning in Canadian universities. Office of Institutional Analysis. Calgary: The University of Calgary, 1982.

Hitch, C.J. and R.N. McKean. The economics of defense in the nuclear age. Cambridge, Mass.: Harvard University Press, 1960.

Hopkins, D.S.P. On the use of large-scale simulation models for university planning. Review of Educational Research, 1971. 41, 467-478.

Hopkins, D.S.P. and W.F. Massy. Planning models for colleges and universities. Calif.: Stanford University Press, 1981.

Hopkins, D.S.P. and R.G. Schroeder (Eds.) New directions for institutional research: applying analytical methods to planning and management. No. 13, San Francisco: Jossey-Bass, 1977.

Jedamus, P. and M.W. Peterson and Associates. Improving academic management: a handbook for planning and institutional research. San Francisco: Jossey-Bass, 1980.

Johnson, C.B. and W.C. Katenmeyer (Eds.) Management information systems in higher education: the state of the art. Durham, N.C. Duke University Press, 1969.

Judy, R.W. and J.B. Levine. A new tool for educational administrators. The Association of Universities and Colleges of Canada. Toronto: University of Toronto Press, 1965.

Keen, P.G.W. "Interactive" computer systems for managers: a modest proposal. Sloan Management Review, Fall, 1976. 19(1), 1-17.

Keen, P.G.W. Decision support systems: translating analytic techniques into useful tools. Sloan Management Review, Spring, 1980. 21(2), 33-44.

Keen, P.G.W. and M.S. Scott Morton. Decision support systems: an organizational

perspective. Reading, Mass.: Addison-Wesley, 1978.

Licklider, J.C.R. Man-computer symbiosis. IRE Transaction on Human Factors in Electronics. HFE 1, 1960, 4-10.

Martin, J. Application development without programmers. Englewood Cliffs, N.J.: Prentice-Hall, 1982.

Mason, T.R. (Ed.) New directions for institutional research: assessing computer-based systems models. No. 9 San Francisco: Jossey-Bass, 1976.

McKean, R.N. Efficiency in government through systems analysis. New York: Wiley, 1958.

Minter, J. and B. Lawrence (Eds.) Management information systems: their development and use in the administration of higher education. Boulder, Colo.: (WICHE), 1969.

Morton, M.S.S. Management decision systems: computer based support, decision-making. Cambridge, Mass.: Division of Research, Harvard, 1971.

Poulton, N.L. (Ed.) New directions for institutional research, evaluation of management and planning systems. No. 31. San Francisco: Jossey-Bass, 1981.

Rochart, S.F. and M.E. Treacy. The CEO goes on-line. Harvard Business Review, Jan/Feb, 1982. 60(1), 82-88.

Schmidtlein, F.A. On analysis of decision strategies employed in the governance of higher education. In R.G. Cope (Ed.) Information for decisions in postsecondary education. The Association for Institutional Research, 1975, pp. 111-11[illegible]

Schroeder, R.G. A survey of management science in university operations. Management Science, 1973. 19(8), 895-906.

Sheehan, B.S. The question of a synthesis in higher education management. In P.J. Plourde and C.R. Thomas (Eds.) Innovative systems: solution or illusion? Proceedings of College and University Systems Exchange 1974. National Conference. Boulder, Colo.: CAUSE, 1975. pp. 133-153.

Sheehan, B.S. (Ed.) New directions for institutional research: information technology: advances and applications. No. 35. San Francisco: Jossey-Bass, 1982 (In press).

Simon, H.A. The new science of management decisions. New York: Harper and Row, 1960.

Sprague, R. DSS-a four part series. In J.D. Couger (Ed.) Computing newsletter for schools of business. Colorado Springs: University of Colorado, Nov. 1980 - March 1981.

Staman, M.E. (Ed.) New directions for institutional research: examining new

trends in administrative computing. No. 22. San Francisco: Jossey-Bass, 1979.

Updegrove, D.A. Using computer-based planning models. In N.L. Poulton (Ed.) New directions for institutional research: evaluation of management and planning systems. No. 31. San Francisco: Jossey-Bass, 1981.

Wallhaus, R. (Ed.) New directions for institutional research: measuring and increasing academic productivity. No. 8. San Francisco: Jossey-Bass, 1975.

Weathersby, G.B. The development and applications of a university cost simulation model. Berkeley: Graduate School of Business Administration and Office of Analytical Studies, University of California, 1967.

Weathersby, G.B. Decision paradigms and models for higher education. Paper presented at 48th meeting of the Institute of Management Sciences and the Operations Research Society of America, November, 1975.

Weathersby, G.B., and M.C. Weinstein. A structural comparison of analytical models for university planning. P-12 Research projects in university administration. Office of the Vice President-Planning and Analysis. Calif.: University of California, 1970.

Wyatt, J.B., J.D. Emery and C.P. Landis. (Eds.) Financial planning models concepts and case studies in colleges and universities. Princeton, N.J.: EDUCOM, 1979.